DOCUMENT RESUME

ED 393 677 SE 057 983

AUTHOR	Verzoni, Kathryn A.
TITLE	Creating Simulations: Expressing Life-Situated Relationships in Terms of Algebraic Equations.
PUB DATE	26 Oct 95
NOTE	13p.; Paper presented at the Annual Meeting of the Northeastern Educational Research Association (Ellenville, NY, October 26, 1995).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Algebra; *Cognitive Development; *Computer Uses in Education; *Equations (Mathematics); Experimental Groups; Grade 8; Junior High Schools; *Junior High School Students; Mathematical Applications
IDENTIFIERS	*Situated Learning

ABSTRACT

This study investigated the development of students' abilities to see connections between algebraic equations and life-situated relationships during an extended problem solving experience. The design problem required students to analyze some aspect of their socio-physical environment for cause and effect and to generate a dynamic model using the MicroWorlds Project Builder programming environment. Eighth grade students (n=49) participated as subjects in a posttest only, intervention/control group design. Students randomly placed in the instructional intervention group participated in a simulation building experience over nine class periods. The posttest measured students' abilities to relate algebraic equations to real life situations and model real life situations in terms of algebraic equations. Control group and intervention group student performances were then compared for differences in representation translation abilities. Results suggest that the simulation building activities developed learners' abilities to make connections between algebraic expressions and life-situated relationships. Appendices contain classroom exams and computer commands. (Author/MKR)

Creating Simulations: Expressing Life-Situated Relationships in Terms of Algebraic Equations

by

Kathryn A. Verzoni,
West Point School

Creating Simulations: Expressing Life-Situated Relationships in Terms of Algebraic Equations

Kathryn A. Verzoni, West Point School
United States Military Academy, Bldg. 705 West Point, NY 10996-1196 (914) 938-2923
Paper Presented at the Annual Meeting of the Northeastern Educational Research Association, Ellenville, NY, Oct. 26, 1995

In this study we investigated the development of students' abilities to see connections between algebraic equations and life-situated relationships during an extended problem solving experience. The design problem required students to analyze some aspect of their socio-physical environment for cause and effect and to generate a dynamic model using the MicroWorlds Project Builder programming environment. Forty-nine eighth grade students participated as subjects in a post-test only, intervention/control group design. Students randomly placed in the instructional intervention group participated in a simulation building experience over nine class periods. The post-test measured students' abilities to relate algebraic equations to real life situations and model real life situations in terms of algebraic equations. Control group and intervention group student performances were then compared for differences in representation translation abilities. Results suggested that the simulation building activities developed learners' abilities to make connections between algebraic expressions and life-situated relationships.

The purpose of this study was to assess the effectiveness of an instructional intervention for developing eighth grade students' abilities to represent life-situated relationships as algebraic equations and to describe algebraic equations in terms of real life situations. Participants used the MicroWorlds Project Builder programming environment to create life-situated models of functional relationships. It was hypothesized that simulation building experience would facilitate learners' understandings of algebraic equations and their power to describe life-situated, functional relationships.

Theoretical Background

Current trends in middle school mathematics education include increased emphasis on developing learners' abilities to represent real life situations with various methods and analyze functional relationships (NCTM, 1989; Wagner & Parker, 1993; Hersberger, Frederick, & Lipman, 1991). These learning outcomes have not traditionally been achieved by mainstream secondary school mathematics students. Instead, emphasis on procedures for manipulation of symbols and solving equations has been associated with weaknesses in students' abilities to connect algebraic representations with real world situations (McCoy, 1994; Monk, 1989; Wollman, 1983).

Several (Verzoni, (in press), Verzoni, 1994; McCoy, 1994; Monk, 1994; Schwartz & Yerushalmy, 1992; Nathan, Kintsch, & Young, 1992) have supported changes in algebra instruction to facilitate students' abilities to translate between multiple representations of functions and map between algebraic equations and life-situated relationships.

These skills are foundations to systems thinking. Richmond (1993) advocates learner-directed learning processes where students use computer-based simulation building environments (eg. Stella) to build understanding of complex interdependent systems. We learn about systems by making models. Model-making fosters development and operational use of formal language (ie. algebra or computer language) in a concrete context (Gurtner, Leon, Nunez, and Vitale, 1993).

Preliminary evidence suggests that certain types of experiences facilitate skill development in expressing connections between various symbolic and concrete representations of functions. In case studies, Monk (1994, 1995) has shown changes in learners' understandings of functional relationships through interaction with "real" objects and events. In addition, early Logo research has shown that programming experiences can facilitate elementary and middle school students' understandings of variables (Nelson, 1986; Noss, 1985). More recently, Hoyles, Healy, and Sutherland (1991) have found that students working collaboratively with Logo develop ability to use formal language as a means for articulating general ideas.

Method

In this study we investigated the development of students' abilities to see connections between algebraic equations and life-situated relationships during a ten-class period model building experience.

Participants

Forty-nine eighth grade students from a middle class, suburban school participated as subjects. Roughly one third of those eighth graders were taking Sequential I (New York State's 9th grade math course) while the remainder of the subjects were in mainstream eighth grade mathematics classes.

Training Intervention

Using MicroWorlds Project Builder (LCSI's newest version of Logo), students were asked to each select an aspect of real life to model. Students defined at least four factors that would have significant effects upon some dependent variable or outcome. Next, they developed equations (in the syntax of Logo) that would indicate, to the best of their abilities, the relationship between the factors and the outcome. This required use of formal language in defining how specified independent variables would effect some dependent variable. The equations and commands for display of output based on factor values were then used in defining procedures that users would run in the use of the simulation.

The MWPB programming environment is especially well-suited for such simulation building as its "slider" enables young programmers with the ability to display a variable storage device directly on the screen (figure 1). User's can then change variable values simply by sliding the node across the slider bar. Our experiences with this new tool lead naturally into its use for representing meaningful factors with meaningful effects.

Figure 1: The MicroWorlds "Slider"

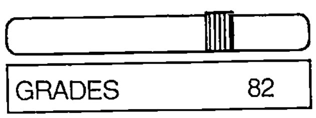


Figure 3: Pancake Simulation User Directions

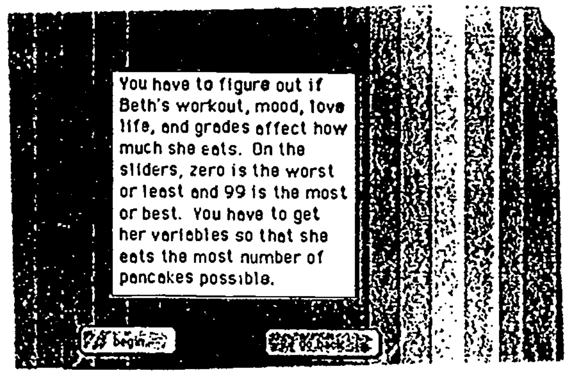
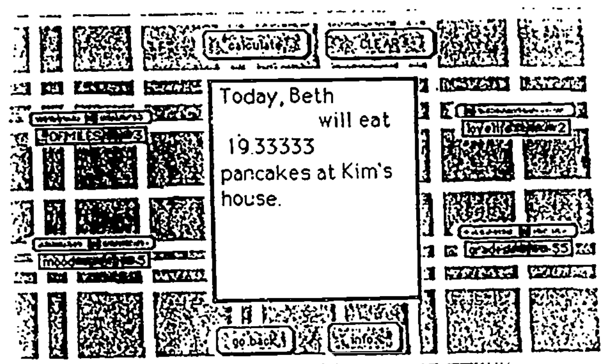


Figure 4: Pancake Simulation User Interaction Screen



Students designed their simulations to communicate outcomes through display of the resulting value for the dependent variable. For example, one student, Kim, modeled factors that might affect how many pancakes her friend Beth would eat at Kim's house (figures 2, 3, and 4).

Figure 2: Pancake Simulation Title Screen

Kim's factors, "#OFMILES" (how far Beth ran that day), "LOVELIFE" (quality of Beth's love life), "MOOD" (the quality of Beth's mood), and "GRADES" (Beth's current average) affected how many pancakes Beth would eat at Kim's house. The variable "MOOD" was actually a trick in that it did not have any affect on the dependent outcome. Kim formalized this make-believe relationship (however inspired by real-life events) with the Logo statement,

```
MAKE "NUMBEREATEN (#OFMILES - LOVELIFE +
        GRADES / 3 )
```

The above Logo statement is equivalent to

NUMBEREATEN = #OFMILES - LOVELIFE + GRADES/3

By analyzing the code we see that (a) the more miles Beth runs that day, the more pancakes she eats, (b) the better Beth's love life the less pancakes she eats, and (c) the better Beth's grade average, the more pancakes she eats. However, since grade averages are usually above 60, the 1/3 weighting factor helps keep that variable reasonable with respect to its affects upon the outcome.

To use the simulation, one sets the sliders, then clicks on Kim's "calculate" button. The calculate button calls a procedure that computes "NUMBEREATEN" then prints out a message with the information.

Each student spent a significant amount of time creating graphics enhanced, user-friendly interfaces to introduce their simulations and entice their use. Students also had time to "try each other's simulations out" during the intervention period. While working with their peers' simulations, students took great pride in figuring out how to "max out" each simulation and were often very interested in studying the code (see for example Logo statement above) that drove it. Finally, a quiz (appendix A) was given on the second to last day of the intervention period. The quiz may have helped some students to make connections between the Logo programming work they had done to create their simulations and more traditional textbook like algebra.

Assessment Instrument

To assess learners' understandings of algebraic equations and their power to describe life-situated, functional relationships, a paper and pencil instrument entitled, "Turning Functions into Real-Life and Turning Real-Life into Functions" was developed (appendix B). This instrument measured three algebra related abilities:

(a) Mapping a linear algebraic equation involving two independent variables to a fantasy or real life situation ($4w + x = y$). Measured sub skills included:

1. thinking up a situation that would logically fit the equation,
2. describing what each variable in the equation would stand for,
3. describing how changes in the independent variables would affect the dependent variable, and
4. accounting for the weighting factor.

(b) Generating an algebraic equation to represent a real-life situation (rating school dances based on number statistics) involving three additive independent variables with weighting factors. Measured sub-skills included:

1. assigning variable names to the factors and outcome,
2. representing the factors as having additive effects, and
3. accurately weighting each factor based on information provided in the problem.

(c) Generating an algebraic equation to represent a real-life situation (amount of water loss out of a pool) where weighting factors are left ambiguous. Measured sub-skills included:

1. assigning variable names to the factors and outcome,
2. representing the factors as having diminutive effects, and
3. weighting each factor based on one's own out-of-school knowledge of the situation.

Students were allowed 21 minutes to work through the three problems. For most students, time was not a limiti ıg factor. However, a non-speeded test would probably be more reliable.

Procedure

A quasi-post test only design was used. In order to preserve equality of academic opportunity and teacher sanity, the research design was somewhat compromised. A random one half of the students were assigned to take the "Turning Functions into Real Life..." assessment on the day prior to the start of the intervention period. Then all students participated in the instructional intervention which lasted nine class periods. The simulation building experience took place during regularly scheduled, heterogeneously grouped computer science and technology classes and was lead by the regular teacher who was also the researcher for this study. Finally, those students who had not taken the assessment before the intervention period took the assessment at the end of the intervention period. The intervention period took place during a time when topics of instruction in neither mathematics nor science classes would contribute to development of assessed abilities.

Control group and intervention group student performances were then compared for differences in the assessed algebra related abilities.

Results and Discussion

To assess the relationship between participation in the computer simulation development experience and ability to relate between algebraic equations and English descriptions of life-situated relationships, a 2x2x3 (training by mathematics class level by problem type) analysis of variance with repeated measures on problem type was computed. Performance on the three problems in the "Turning Functions into Real Life..." assessment served as the dependent variables. Means and standard deviations are provided in tables 1 and 2.

Table 1. Means and standard deviation for simulation building experience and no-experience group subjects' performances on the "Turning Functions into Real Life..." assessment.

	SBE group			No-E group		
Problem	n	mean	SD	n	mean	SD
EQ to words	26	3.0	.219	23	2.3	.263
Words to EQ w/ weighting	26	2.6	.259	23	1.5	.312
Words to EQ wo/ weighting	26	2.7	.230	23	1.6	.277

Table 2. Means and standard deviation for accelerated math and regular math group subjects' performances on the "Turning Functions into Real Life..." assessment.

	Accel Math group			Reg Math group		
Problem	n	mean	SD	n	mean	SD
EQ to words	15	3.1	.316	34	2.2	.188
Words to EQ w/ weighting	15	2.4	.375	34	1.8	.223
Words to EQ wo/ weighting	15	2.4	.333	34	1.9	.198

The significant main effect for training indicated that instructional intervention group participant test performances were superior to those of control group participants ($F(1,45) = 14.46$, $p<.01$). The effect for mathematics class level (whether mainstream grade 8 or accelerated Sequential I) was also significant ($F(1,45) = 9.26$, $p<.01$). Interaction effects between (a) training and mathematics class level, (b) problem type and training, and (c) problem type, training, and mathematics class level were not significant. This indicated that the simulation building experience was associated with superior performance on assessment problems regardless of problem type and mathematics class level. These results are summarized in table 3 and in figures 3 and 4.

Table 3. Results of 2x2x3 ANOVA with Respect to the Effects of Training, Mathematics Class Level, and Problem Type on Performance in Relating Between Algebraic Equations and Life Situations (N = 49)

Source of Var.	SS	DF	MS	F	Sig F
Between Subjects					
Within Cells	89.69	45	1.99		
Training (A)	28.81	1	28.81	14.46	.000
Math C L (B)	18.46	1	18.46	9.26	.004
A x B	.50	1	.50	.25	.620
Within Subjects					
Within Cells	78.03	90	.87		
Prob Type (C)	7.14	2	3.57	4.12	.019
A x C	.93	2	.47	.54	.586
B x C	.66	2	.33	.38	.684
A x B x C	6.10	2	3.05	3.05	*.034

*Wilks' Lambda = .893 F-Statistic = 2.65 DF=2, 44 PROB = .082

This research suggests that simulation building activities experienced by regular, young adolescent students in a natural school setting can contribute to development of certain aspects of algebraic skill. Particularly, the ability to relate arbitrary algebraic equations to life-situated relationships and vice versa. However, the post-test only design of the study and unavailable test reliability data limit conclusions that can be drawn regarding ability gains. A next step may be to conduct a similar study using random assignment in a pre test - post test design.

Figure 5: Instructional Intervention and Control Group Means for the Three Translation Problems

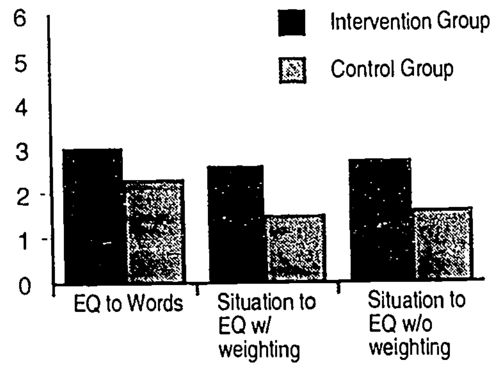
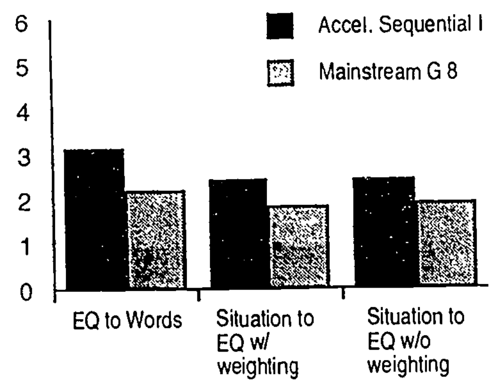


Figure 6: Accel SEQ I and Mainstream G8 Math Group Means for the Three Translation Problems



Perhaps, however, even that would be missing the point. I'm not sure that the gains students show on paper and pencil translations between equations and English representations of life-situated relationships are what's most important here. The current algebra reform movement (Kaput, 1995a, p. 5) places importance on building upon children's language learning abilities and their natural generalizing and abstracting powers in order to deepen and extend their reasoning about quantity, number, space, data, and uncertainty. Maybe what is most important here is that the reported activity provides an example of learners engaged in using their intuitive notions about the dynamics of the world about them as a footing for beginning generalizing, abstracting, and formal language communications efforts. These types of activities form a semantic starting point for syntactically guided

manipulation of formalisms (Kaput, 1995b).

For now, the contribution that this study makes is in its description of a simulation building activity that is rich in two basic ways. (a) It shows learners that values of variables do continually change and that equations using variables can and should be used to describe meaningful, fluid relationships. (b) It involves learners in reasoning about systems dynamics and motivates their needs for use of formal language and generalized arithmetic beyond realms typically associated with school algebra.

Often in math education we place so much importance on solving for the unknown variable that the idea of a variable as something that actually varies gets lost. By having students use the MicroWorlds slider and the Logo language to express life-situated relationships, we encourage their view of algebra (if they realize it's algebra) as a tool for studying relationships among changing quantities. This view establishes value to algebra in kids lives beyond meaningless symbol manipulation.

In addition, when students conjure up their own life-situated relationships to model, there is an almost guarantee that the relationships that they model will be meaningful. Meaningful in their minds, that is. As adults, we make good attempts at creating problems that students will find meaningful, yet what else might be meaningful or more meaningful in the mind of each student is invisible until we encourage their creation of the problems.

Kim's "How many pancakes will Beth eat at Kim's house?" is a prime example. What may seem trite in the mind of an adult can be very meaningful in the mind of an eighth grader. The reverse, too is surely true.

When developing their models, students often found themselves faced with difficulties in describing relationships in terms of equations. When creating a model of within-bounds tennis ball return probability, Garrett (appendix C) found himself in need of language that would make middle values best, minimum and maximum values worst, and gradual effect changes as variable values changed for two variables: RACQUET.ANGLE and RACQUET.SPEED. Having no formal knowledge of parabolas or what might happen to y values when x values are squared, Garrett eventually came up with this solution to his problem...

```
IF RACQUET.ANGLE < 90
   [MAKE "ANGLEQUALITY RACQUET.ANGLE]
IF RACQUET.ANGLE > 89
   [MAKE "ANGLEQUALITY 90 - (RACQUET.ANGLE - 90)]
```

In more algebraic-like language, this translates to

IF $x < 90$ THEN do this...

$y = x$

But, IF $x > 89$ THEN do this...

$y = 90 - (x - 90)$

Garrett was the first to come up with such a strategy and it was neat to watch his technique spread as he showed classmates, who showed classmates, who showed kids from other classes. The algebra learning that went on was unique as it developed from a true need in the mind of the student, rather than a teacher's perceived need because it was what was next in the textbook.

While developing a soccer simulation entitled, "Will your player score a goal?" Avery asked, "How can I make small ball sizes good for players with little talent and big ball sizes good for players with lots of talent? This was another instance of algebraic learning arising out of learner need. With much coaching, he finally came up with an intriguing solution.

```
MAKE "ADJ.BALL.SIZE BALL.SIZE * 20
IFELSE :ADJ.BALL.SIZE > KICKER.TALENT
      [MAKE "SIZE.TALENT.MATCH
         :ADJ.BALL.SIZE / KICKER.TALENT]
      [MAKE "SIZE.TALENT.MATCH
         KICKER>TALENT / ADJ.BALL.SIZE]
```

This translates to

$x' = 20x$

IF $x' > w$ THEN DO THIS

$y = x' / w$

OTHERWISE, DO THIS

$y = w / y'$

Although Avery had no formal knowledge of interaction effects, that was what he needed and eventually defined. This was quite a sophisticated idea, made accessible through motivation driven by learner need.

Current literature reflects a growing interest in making school learning readily applicable to life outside school. However, we also need to engage students in applying out-of-school knowledge in school situations. Problems set within meaningful context facilitate learners' use of out-of-school knowledge when learning in-school mathematics. Carraher, Carraher, and Schliemann (1987) found enhanced problem solving performances among children when problem contexts evoked "street know-how," rather than school-learned algorithms. As demonstrated in this research, it seems that this out-of-school knowledge is a resource that should be tapped in our efforts to help our students grow in mathematical power. Specifically, to grow in their abilities to generalize to abstract representations from concrete instances and to apply formal language as a useful tool in meaningful pursuits.

References

Carraher, T., Carraher, D., & Schliemann, A. (1987). Written and oral mathematics. *Journal for Research in Mathematics Education*, 18(2), 83-97.

Gravemeijer, K. (1993). The empty number-line as an alternative means of representing addition and subtraction. In J. deLange, C. Keitel, I. Huntley, and M. Niss (Eds.) *Innovation in maths education by modeling and applications*. NY: Ellis Horwood.

Gurtner, J. L., Leon, C., R. Nunez, and Vitale. B. (1993). The representation, understanding and mastery of experience: Modeling and programming in a school context. In J. deLange, C. Keitel, I. Huntley, and M. Niss (Eds.) *Innovation in maths education by modeling and applications*. NY: Ellis Horwood.

Heid, M. K. (1995). *Algebra in a technological world*. Reston, VA: NCTM

Hersberger, J. Frederick, W. and Lipman, M. (1991) Discrete mathematics in the traditional middle school curriculum. In M. J. Kenney and C. R. Hirsch (Eds.) *Discrete mathematics across the curriculum*. 1991 yearbook. Reston, VA: NCTM

Hoyles, C., Healy, L., & Sutherland, R. (1991). Patterns of discussion between pupil pairs in computer and non-computer environments. *Journal of Computer Assisted Learning*.

Kaput, J. (1995a). *The early development of Algebraic reasoning*: Draft papers for the NCTM Research Presession Symposium. April 1995, Boston.

Kaput, J. (1995b). *Six strands of algebraic reasoning*. Draft paper for presentation at PME-NA, Fall 1995, Columbus.

McCoy, L. P. (1994). *Multiple representations of algebra problems*. Paper presented at the American Educational Research Association Annual Meeting, April 1994, New Orleans.

Monk, G. S. (1994). *How students and scientists change their minds*. A Revision of an MAA Invited Address to the Joint Mathematics Meeting, Cincinnati, Ohio, January, 1994.

Monk, G. S. (1989). *A framework for describing student understanding of functions*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, California.

Monk, G. S. (unpublished manuscript). *Students' understanding of functions in calculus courses*. Department of Mathematics, GN-50, University of Washington, Seattle, WA 98195.

Nathan, M. J., Kintsch, W., and Young, E. (1992). A theory of algebra-word-problem comprehension and its implications for the design of learning environments. *Cognition and Instruction*. 9, 329-389.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluations standards for school mathematics*. Reston, VA: NCTM.

Nelson, G. T. (1986). *Development of fourth-graders' concept of literal symbols through computer-oriented problem-solving activities*. Dissertation Abstracts International, 47, 2607A. (University Microfilms No. DA8526359).

Noss, R. (1985) *Creating a mathematical environment through programming: A study of young children learning Logo*. Unpublished doctoral dissertation, Chelsea College, University of London, London, England.

Richmond, B. (1993). Systems thinking: critical thinking skills for the 1990s and beyond. *Systems Dynamics Review*. 9, 113-133.

Schwartz, J. and Yerushalmy, M. (1992). Getting students to function in and with algebra. In G. Harel and E. Dubinsky (Eds.) *The concept of function: Aspects of epistemology and pedagogy*.

Verzoni, K. A. (1994). Modeling real life with MicroWorlds Project Builder. *Logo Update* 2(3), 3.

Verzoni, K. A. (in press). Modeling integer operations. *CLIME Connections*. Newsletter of NCTM's Council for Logo and Technology in Mathematics Education.

Wagner, S. & Parker, S. (1993). Advancing Algebra. In P. Wilson (Ed.), *Research ideas for the classroom: High school mathematics* (pp. 119-139). New York: Macmillan.

Wollman, W. (1983). Determining the sources of error in a translation from sentence to equation. *Journal for Research in Mathematics Education*. 14, 169-81.

APPENDIX A

COMPUTING WITH VARIABLES

MWPB Exam

Name: ____________________ Section: X Y Z

For questions 1 through 5, refer to the code for "The Bungee Trip"

1. When the value to the variable called **clothing** is set to 3, what is the value of **co.of.drag**? ______

2. How many times is the procedure called *second* called? ______

3. From the code, you can learn a little physics... What formula determines frictional force?

____

4. If the value for the variable called **momentum** equals 20 and the value for the variable called **mass** equals 5,

   what is the value for the variable called **velocity**? ______

5. Let y stand for **restoringforce**
   Let m stand for **hooke**
   Let x stand for **disp**

   Using y, m, and x --write the formula for restoring force

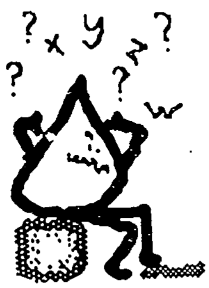
____

For items 6 and 7, refer to the code for Detention Days

6. Fill in the missing values on the chart.

detention days	mood	warnings	spitballs	workdue * .3
8	5	2	5	1
	6	2	5	2
19	7		5	3
11	10	3		1
9	5	2	3	
6		1	3	1

APPENDIX B



Turning Functions into Real-Life
and
Turning Real-Life into Functions

Name: ____________________ **Section:** X Y Z

K. Verzoni, 5/94

1. Here's a math equation.

$$y = 4w + x$$

The letters y, w, and x stand for variables.

- Think up a real-life situation that this equation might describe. (The situation you come up with can be silly or serious.)

- Describe what each variable in the equation could stand for.

- Then write a sentence or two that explains how changes in whatever "w" and "x" stand for affect whatever "y" stands for. Use pictures or diagrams to help you explain if you'd like.

w stands for ____________________

x stands for ____________________

y stands for ____________________

How changes in whatever "w" stands for and whatever "x" stands for affect changes in whatever "y" stands for...

2. Rating School Dances

Richard is student council president at Morgan High School. Six dances are planned for the year and he wants to set up a rating scale so that he can rate the quality of each dance. Richard decides that these factors will contribute to the rating score:

- **the number of students attending the dance** (Give one point for every 10 students who attend.)
- **the number of students that danced the first dance** (Give one point for every 5 students that dance the first dance.)
- **the number of students that danced the last dance** (Give one point for every 7 students that dance the last dance.)

Write an equation that he can use to establish an overall dance quality rating.

3. Predicting Water Loss

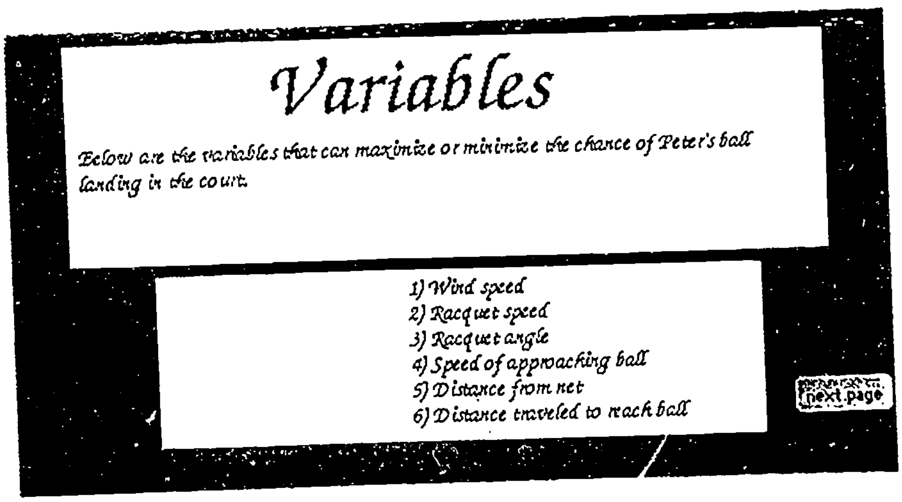
Sharisha is setting up the kiddie pool for her twin three-year old brothers. As she fills the pool, she wonders how much will be left after her brothers have played in it for 20 minutes. Sharisha decides that these factors will affect the amount of water that will be left:

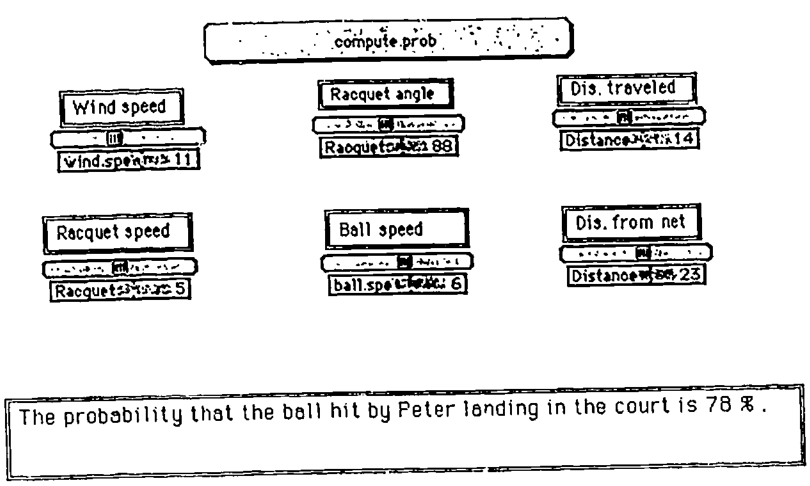
- **the starting amount of water in the pool**
- **the number of times one of the boys gets out of the pool**
- **the number of minutes the boys spend splashing each other**

Write an equation that might predict the amount of water left in the pool after her brothers have played in it for 20 minutes.

APPENDIX C

```
To go.on
getpage "page2
end

to next.page
getpage "page3
end

To prob
if racquet.angle < 90 [make "anglequality  racquet.angle]
if racquet.angle > 89 [make "anglequality  90 - (racquet.angle - 90)]
if racquet.speed < 5 [make "speedquality racquet.speed]
if racquet.speed > 4 [make "speedquality 5 - (racquet.speed - 5)]
make "probability ((ball.speed + :anglequality * 2 + wind.speed + :speedquality) -
(distance.traveled + distance.from.net) + 6)
if :probability < 47 [ make "probability :probability - 21]
if :probability > 75 [ make "probability :probability + 10]
make "probability round (:probability) / 226 * 100
end

to type.message
talkto "text1 ct
insert [The probability that the ball hit by Peter landing in the court is]
insert char 32
insert :probability
insert char 32
insert [%]
insert char 32
insert [.]
end

to compute.prob
prob
type.message
end
```

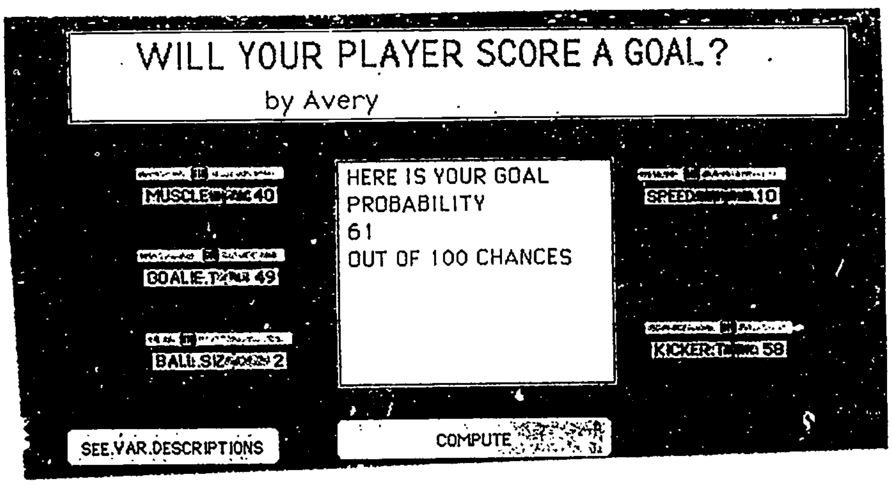


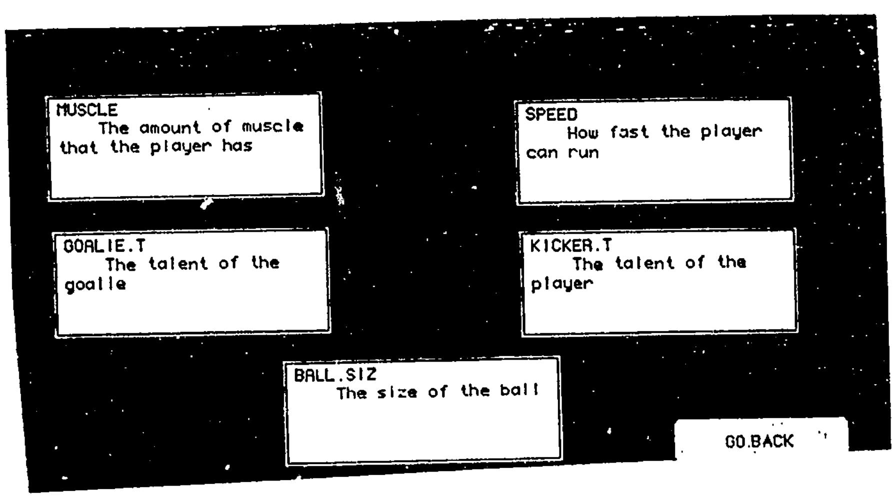


BEST COPY AVAILABLE

APPENDIX D

```
TO GO.BACK
GETPAGE "PAGE1
END

TO SEE.VAR.DESCRIPTIONS
GETPAGE "PAGE2
END

TO TYPEMESSAGE
TALKTO "TEXT1
CT
PRINT [ HERE IS YOUR GOAL PROBABILITY]
PRINT :GOAL.PROB
PRINT [OUT OF 100  CHANCES]
END

TO COMPUTE
MAKE "ADJ.BALL.SIZE   BALL.SIZE * 20
IFELSE :ADJ.BALL.SIZE  >  KICKER.TALENT  [MAKE "SIZE.TALENT.MATCH :ADJ.BALL.SIZE  / KICKER.TALENT]   [MAKE
"SIZE.TALENT.MATCH   KICKER.TALENT  /  :ADJ.ball.size]
IFELSE SPEED  <  15 [ MAKE "SPEED.QUAL SPEED ] [ MAKE "SPEED.QUAL 16 - (SPEED - 14) ]
MAKE "GOAL.PROB  (MUSCLE  -  :SIZE.TALENT.MATCH   -  GOALIE.TALENT  + :SPEED.QUAL +
183)  /  3
MAKE "GOAL.PROB ROUND (:GOAL.PROB)
TYPEMESSAGE
END
```





BEST COPY AVAILABLE